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Project-based plant morphology module as teaching material for students' concept mastery

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ABSTRACT

The necessity for teaching materials that can effectively facilitate students' skills has become increasingly evident in order to enhance concept mastery. The objective of this study is to develop teaching materials in the form of project-based modules on plant morphology for the purpose of facilitating concept mastery. The Project-Based Plant Morphology Module was developed in accordance with the ADDIE model (Branch, 2009), which comprises five phases: analysis, design, development, implementation, and evaluation. The research instruments utilized for the development process included a validation questionnaire, a student response questionnaire, and a concept mastery test. Validity of the module was obtained through the use of instruments in the form of book validation sheets, which were completed by experts in the fields of media, materials, and education. The module trials were obtained through the implementation instruments for the individual components and the management of the learning implementation. Product trials will be conducted with students enrolled in the Biology Education program during the second semester of the 2022/2023 academic year. The data used to validate the module was obtained from the module's expert validators using a validation sheet. The data obtained from the product trial is analyzed in order to assess the readability of the module. The results indicated that the plant morphology module was classified as "very feasible." The responses of students to the module indicated that it was categorized as "very easy to understand". Consequently, the plant morphology module is deemed a valuable and effective component of plant morphology courses

INTRODUCTION

Biology is the primary and fundamental science in everyday life. In the learning process, students accept information, apply procedures, and develop their knowledge (Dikmenli & Cardak, 2010). The acquisition of knowledge by learners is contingent upon their ability to master the concept of learning materials and to benefit from suitable learning conditions (Mitee & Obaitan, 2015). Consequently, through the process of learning, students can achieve mastery of the material (Suwono et al., 2017).

The term "conceptual" is also used to refer to qualitative reasoning (Sands, 2014). The processes and objects involved in the assessment of conceptual mastery can be evaluated through the application of reasoning. The attainment of conceptual mastery is the result of a high-level, coordinated cognitive process that is directed towards the achievement of specific goals (Stalvey et al., 2018). The development of conceptual knowledge can be classified into three categories: strong, moderate, or weak; and conversely, can be grouped into three categories: flat, increasing, or decreasing (Robinson et al., 2018) The conceptual development of students depends on which subject matter concepts are being assessed, underscoring the need for multiple concepts to be investigated simultaneously. The development of conceptual knowledge can be classified as strong, moderate, or weak, and can also be grouped as flat, increasing, or decreasing. This is evidenced by learning outcomes (Robinson et al., 2017). Fundamentally, a lecturer is aware of which students have achieved mastery of concepts, knowledge, and skills and which have not, thus enabling further improvements to be made (Mitee & Obaitan, 2015). Mastery of this concept must also be demonstrated by students of plant morphology courses and should be facilitated by innovative teaching materials.

The department and study program of biology education includes a course on plant morphology. Plant morphology is the scientific study of the shape and configuration of the external structure of plants(Tjitrosoepomo, 2012). The study of the plant's external structure encompasses the morphological attributes of diverse species in response to varying precipitation levels and developmental conditions (Yan et al., 2021). In the learning process, students engage in discourse using learning resources in the form of instructional materials. The teaching materials utilized by students are pertinent to the problem-solving process. The concepts studied include the morphological structure of leaves, the metamorphosis of roots, stems, and leaves, and the morphology of flowers, fruits, and seeds (Tjitrosoepomo, 2012). Upon completion of this course, students will be able to analyze the fundamental concepts of the morphological structure of plant organs and will have acquired the ability to identify plant organs based on morphology. It is thus evident that the utilisation of innovative teaching materials is a crucial aspect in the enhancement of students' conceptual understanding, particularly within the context of learning resources

Teaching materials are a series of narratives that elucidate the processes through which content is conveyed and acquired at all levels, serving as a fundamental element of the subject matter (Roberts et al., 2021). It is thus incumbent upon students to not only master the subject matter but also to be able to articulate it accurately (Chiappetta & Fillman, 2007). Teaching materials are frequently utilized to disseminate a plethora of authentic scientific data to learners (Chiappetta & Fillman, 1991). Consequently, teaching materials encapsulate the curriculum and priorities classroom learning (Chaisri & Thathong, 2014). Furthermore, teaching materials should facilitate the enhancement of students' conceptual understanding.

The formation of misconceptions is influenced by several factors, particularly within the context of plant morphology courses. One such factor is the unavailability of suitable teaching materials that could assist lecturers in effectively delivering the material. The optimal teaching materials would integrate theoretical knowledge and practical experimentation in a manner that facilitates students' comprehension of plant morphology and enhances their understanding based on the analysis of their own experiences (Moundy et al., 2022; Roberts et al., 2021). The findings indicated that students who utilized the teaching materials for the majority of the lesson were more inclined to engage in problem-solving activities with their peers (Archer-Bradshaw, 2017). The results of the observation of teaching materials utilized in plant morphology courses have remained consistent. Students tend to focus on a single printed teaching material. It is evident that the effective utilization of teaching materials is of paramount importance in facilitating students' comprehension of the biological concepts pertaining to plant morphology. Furthermore, such materials can play a pivotal role in enhancing students' abilities and fostering creativity. The skills required for success in this field

include (1) critical thinking, (2) problem-solving, (3) metacognition, (4) communication, (5) collaboration, (6) innovation and creativity, and (7) information literacy (Mardhiyah, et al., 2021). These skills are not innate; rather, they are acquired through practice, learning, or experience (Redhana, 2019). Furthermore, the learning process should commence with the posing of challenging questions concerning a given phenomenon, followed by the assignment of an activity (project) that emphasises the collection and utilisation of evidence and the teaching of science as it is conducted (Lawson, 1995). Therefore, the provision of teaching modules that enable students to engage more actively in activities is a crucial necessity in plant morphology courses.

The enhancement of educational quality is progressing at a rapid pace in conjunction with the advancement of scientific and technological fields. One such factor is the impact on learning resources. Learning resources are defined as any entity that can provide specific information to a given community. One potential learning resource is a teaching module (Simpson et al., 2021). In this context, the module functions as a learning tool that can assist students in comprehending the material presented by the lecturer, thereby preventing the formation of misconceptions (Košir & Lakshminarayanan, 2021). Teaching materials in the form of modules can facilitate discussions about the nature of science, engage students in gathering information, and conduct laboratory and field investigations. These investigations may explore topics such as the relationship between science, technology, and society (Endang, 2010). This learning resource is aligned with numerous objectives of science education, including an understanding of the nature of science, scientific inquiry, technology, appreciation of science, attitudes towards science, and decision-making (Chiappetta & Fillman, 2007).

It is thus imperative to develop instructional materials in the form of learning modules to facilitate the conveyance of information to students to enhance their conceptual understanding. The availability of teaching modules that facilitate students' active engagement in learning activities is expected to enhance their conceptual understanding (Alsalhi, 2020) (Kemdikbud, 2017). Considering the aforementioned issues, it is imperative to introduce a novel approach through the creation of instructional materials in the format of modules that prioritize student competencies and are project-based in nature. This approach is designed to enhance students' comprehension of biological concepts. Furthermore, it facilitates independent learning, enabling students to utilize the material even when they are not in the classroom. The development of a project-based Plant Morphology Module is anticipated to facilitate students' acquisition of the desired concepts.

To achieve continuous improvement, lecturers must cultivate positive attitudes towards scientific concepts. The formation and development of lifelong learning skills are essential for ensuring the capacity to investigate and educate about scientific developments (Dragoş & Mih, 2015). Similarly, the objective of learning outcomes is to benefit students and facilitate their capacity to engage in the development and evaluation of their academic pursuits. The utilisation of learning outcomes may result in unforeseen consequences if the theoretical foundation of the concept is not duly considered or is not fully understood. Modules utilized as filler material must present a substantial and reliable source of information. The material should be organized systematically and coherently, comprising a diverse range of information. Moreover, the material must possess a compelling quality that will stimulate students' interest in the subject matter. Consequently, teaching materials such as modules should present challenges, stimulate interest, and provide support for student activity and creativity (Sakri, 2008). In the current era, it is unfeasible to avoid changes; thus, it is imperative to adequately prepare human resources (HR) to adjust and compete on a global scale. The enhancement of human capital through educational avenues, spanning from primary and secondary education to higher education, represents a pivotal strategy for maintaining competitiveness in the context of the Industrial Revolution 4.0.

According to the aforementioned description, the development of teaching materials aimed at fostering students' competencies in conceptual understanding is imperative. A notable exemplar of this approach is the Project-Based Plant Morphology Module, which has been instrumental in facilitating the mastery of essential skills among students.

METHODS

Research Design

This research project is a development of a project-based plant morphology module to improve concept mastery. The development of this project-based plant morphology module employs

the ADDIE model, which encompasses the following five phases: Analysis, Design, Development, Implementation, and Evaluation (Aldoobie, 2015; Branch, 2009; Gordon, 2009). The research was conducted over the period from April to October 2023. The trial was conducted on students enrolled in the Plant Morphology course within the Biology Education Study Program at Universitas Bengkulu.

Instrument

The research was conducted over the period from April to October 2023. The trial was conducted on students enrolled in the Plant Morphology course within the Biology Education Study Program at Universitas Bengkulu.

Procedure

The following is a description of the procedure for developing plant morphology modules.

1. The analysis phase entails a needs assessment to ascertain the students' requirements regarding the teaching materials. The resulting output is in the form of a description of the learner characteristics, identification of needs, and a detailed task analysis based on the aforementioned needs.
2. The design stage entails the configuration of the module structure and the module content framework in alignment with the insights gleaned from the analysis phase. The culminating output is an initial draft of the module tailored to the specific characteristics of the learners and the demands of the CPMK. Additionally, the identification of pivotal concept material within the project-based module developed necessitates the selection of suitable media, the determination of optimal teaching material formats, and the formulation of preliminary designs.
3. The term "develop" encompasses the processes of creating, developing, and modifying project-based modules. These modules are designed to achieve defined learning outcomes. In addition to this, the modules are enhanced with a range of supplementary materials, including illustrations, charts, and graphs. The modules are also structured with a clear layout and evaluation test questions that assess the learners' understanding of the subject matter. Moreover, a formative evaluation of the development process was conducted based on feedback from educational experts and practitioners, as well as the validation questionnaire. Subsequently, the developed module should be revised prior to its implementation or testing in the field. According to the results of the preliminary trial, this improvement may be carried out on more than one occasion, thus ensuring that the main module draft is ready for wider testing.
4. The implementation stage involves the utilisation of the module in learning activities, to determine the readability of the module and its effect on the quality of learning. This is assessed in terms of its effectiveness, attractiveness and efficiency in a sample of 30 students. The implementation stage is conducted in small groups to obtain feedback from students and lecturers, which is then used as material for the improvement of the product draft.
5. The evaluation process is undertaken to ascertain the extent to which the learning system being constructed is meeting the initial expectations set out for it. This encompasses both formative evaluation, which is conducted to facilitate improvement, and summative evaluation, which is carried out after the program to determine the extent to which students have mastered the concepts being taught and to assess the overall quality of the learning experience. In this study, only formative evaluation was conducted, as this type of evaluation is pertinent to the stages of development research to improve the resulting development product. The evaluation was conducted on a stage-by-stage basis.

Data Analysis Techniques

The data obtained from the trial included both qualitative and quantitative data. The quantitative data were obtained from the validation sheet of the project-based plant morphology module by both expert validators and practitioners. These data were based on indicators of concept mastery. The qualitative data were in the form of comments, suggestions, and criticisms given by respondents from the module validation. These data were collected using the Guttman scale, namely the checklist and Likert Scale. The score data obtained were averaged for each aspect. These averages were then converted into percentages (Arikunto, 1997).

The validation questionnaire was subjected to qualitative and quantitative analysis. The data utilized in this process were derived from the Module validation questionnaire. The score data obtained were averaged for each aspect and subsequently converted into a percentage (Johnson & Johnson, 2002)

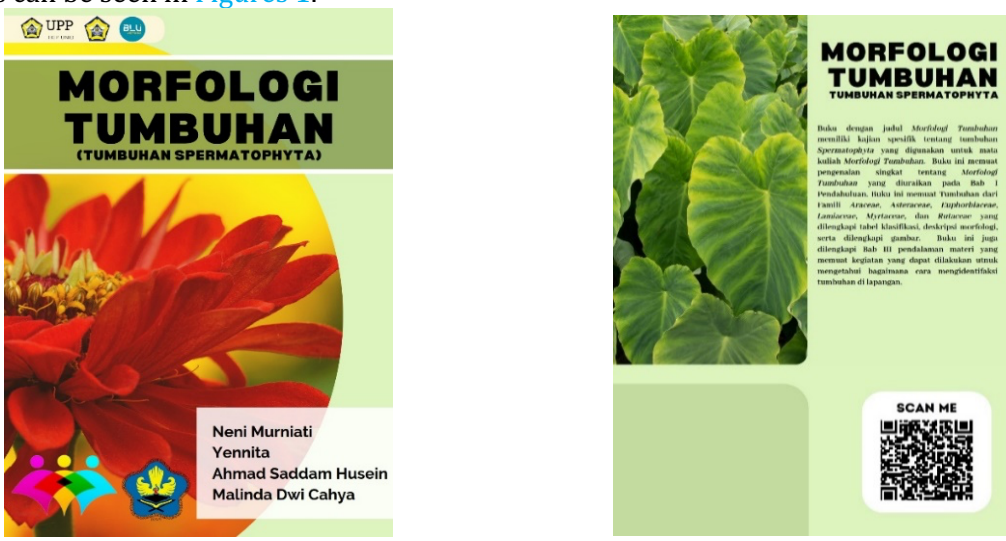
Furthermore, to measure the consistency of the reliability of the assessment of plant morphology modules and learning devices by validators using the percentages agreement coefficient > 70 (Drost, 2011). The following criteria are used to determine the degree of consistency and reliability in the validator assessments of the plant morphology module model presented (Akbar, 2017)

The student response data to the module was analyzed using a student readability response questionnaire. The data was then calculated and presented in Table 3, which shows the percentage of students who responded with a score that met the criteria for module readability (Riduwan, 2015)

RESULTS AND DISCUSSION

1. Results of Plant Morphology Module Design Development.

The results demonstrated that species belonging to the Angiospermae class were developed into educational materials in the form of modules. The results of the design of these plant morphology modules can be seen in Figures 1.



(a) (b)

Figure 1. Cover design of plant morphology module; (a) front cover (b) back cover; QR code

The following text provides a detailed description of the components that comprise the project-based plant morphology module teaching materials. The module cover is designed with an aesthetically pleasing combination of green, yellow, and other colors. The front cover includes the author's name, logo, module title, and illustrative examples of angiosperms. The reverse side of the cover is green in color and features a *Zinnia elegans* plant, a concise description of the module, and a Quick Response (QR) code that facilitates online access to the module (Figure 1). The pages between ii and iv contain a preface, table of contents, and glossary. The glossary features an animated leaf background that is made transparent so as not to affect the writing of the module content. 3)Chapter I, entitled "Introduction," contains the following elements: (1) an enumeration of the course outcomes for the plant morphology module; (2) a succinct description of plant morphology; (3) an explication of the rationale and relevance of the module; and (4) instructions for using the module.

Chapter II, entitled "Angiospermae Plant Morphology," spans pages 9 through 33. It contains images of Angiospermae plant species, accompanied by information in the form of photos, classification, and descriptions of each species. The background is white, and the images are accompanied by animations. The *families Araceae, Asteraceae, Euphorbiaceae, Lamiaceae, Myrtaceae,* and *Rutaceae* are presented in a blurred state to avoid interference with the content. Each family is accompanied by evaluation questions.

Chapter III comprises activities designed to facilitate deeper engagement with the subject matter. These include plant herbarium activities and activities to identify single leaf morphology,

compound leaf morphology, stem morphology, root morphology, flower morphology, and fruit morphology using a blurred leaf background. The teaching materials have been subjected to validation by media experts, material experts, and biology teachers. The results of this validation are presented in Table 6 and Table 7.

2. Data from Module Validation by Experts

The validation of project-based plant morphology modules is conducted by biology education expert validators based on the following criteria: content feasibility, presentation, language, size, cover design, and content. The results of the validation analysis of the project-based plant morphology module indicate an average score of 4.47, indicating that the project-based plant morphology module can be utilized with minor revisions, specifically to address deficiencies in the media component of the module. Additionally, project-based plant morphology modules have been deemed valid with a validity percentage of 91.4% (Table 6). Furthermore, the validation of the plant morphology module was accompanied by recommendations and feedback from the validators (Table 7).

Table 6
Mean validation score of Plant Morphology Module.

No.	Assessment Indicators	$\underline{X}$	R (%)	Note
1	Content eligibility	4.33	93.4	Valid
2	Presentation feasibility	4.29	92.3	Valid
3	Language feasibility	4.63	90.3	Valid
4	Size	4.80	90.7	Valid
5	Module cover design	4.37	91.1	Valid
6	Module content design	4.40	91.1	Valid
Average		**4.47**	**91.4**	**valid**

Notes: X= Average, R= Percentage agreement, V= Valid

Table 7
Suggestions and Revisions of Plant Morphology Module Development

No	Prototype I of Plant Morphology Module	Revision Result
1	Further illustrative examples may be drawn from the campus environment.	Followed up
2	The text was augmented with motivational language to reinforce the message.	Followed up
3	In order to comply with the standards, set forth by the UNESCO, it is necessary to widen the right margin of the module	Followed up
4	The colors utilized in the module's design should be more harmonious and transparent, as illustrated on pages 1 to 4.	Followed up
5	It would be beneficial to include more detailed and illustrative descriptions in order to gain a more comprehensive understanding of the subject matter.	Followed up
6	It is recommended that the front page of the module display the families included in the module.	Followed up
7	The images of plant morphology at the conclusion of the text should be accompanied by appropriate labels and descriptions.	Followed up
8	The placement of the chapter title, situated in the middle of the page, should be adjusted to a more elevated position.	Followed up
9	It is recommended that the illustration and font size of the title be reduced slightly so that it is more proportional to the content below.	Followed up

3. The Mean Response to the Plant Morphology Module

The mean student response to the Plant Morphology Module can be described as a positive evaluation, indicating that the material was perceived as relatively straightforward (Fig. 6). In general, students responded to the display aspect with a score of 4.34, the material presentation aspect with a score of 4.44, and the benefit aspect with a score of 4.26. The mean score for student responses to the plant morphology module was 4.34, representing a percentage of 86.9%. This indicates that the module is categorized as "very easy to understand." In accordance with the established criteria for student response ($4 \leq TK < 5$), it can be concluded that the student response to the plant morphology module is satisfactory.

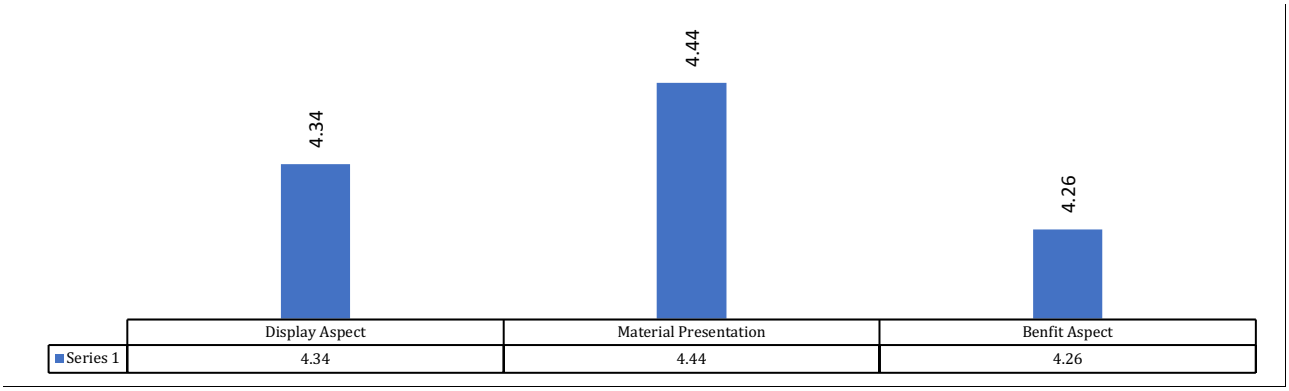


Figure 6: Results of Response to the Plant Morphology Module

The development of this project-based plant morphology module is based on the feasibility of teaching materials, which consist of a presentation, content, language, and the size and design of the module itself. In the plant morphology module, this objective has been met based on the results of the assessment by the validator, who awarded a score of 91.4%. The plant morphology module has enabled students to engage in project-based activities that are designed to enhance their ability to grasp concepts. The incorporation of science process activities has been demonstrated to enhance both concept mastery and process skills (Demirel & Caymaz, 2015). Moreover, it is asserted that concept mastery is gauged based on knowledge (perception) as a consequence of individual endeavors to comprehend the material they are learning (Nasution, 2006; Robinson et al., 2017). Accordingly, the extent to which students can demonstrate an understanding of the material is contingent upon their ability to recall information, comprehend ideas, apply knowledge, analyze concepts, evaluate information, and synthesize ideas (Anderson & Krathwohl, 2001).

The project-based plant morphology module comprises activities that require students to recognize plants and identify their outer structures with guidance from lecturers. The involvement of lecturers in student learning activities has been shown to encourage direct engagement (Hughes et al., 2017; Klein et al., 2009). The constant provision and receipt of information through the sensory organs allows students to select information based on their preferred cognitive processes, which may differ from the preferred mode of information reception (Le Roux, 2011).

The process of learning plant morphology through the plant morphology module will facilitate the scientific method. In addition to enhancing scientific process abilities, the plant morphology module provides students with the opportunity to engage directly with the application of biological concepts and the subsequent demonstration of their veracity. Group-based investigations facilitate active learning and facilitate the discovery and reinforcement of conceptual understanding (Gozuyesil & Dikici, 2014; Gyamah, 2022). It is anticipated that students will successfully collect data and engage in discussions to analyze their findings and present these results through open discussions, which will facilitate evaluation and the identification of answers. The discussion serves as a communication platform, providing students with the freedom to express their opinions and transfer knowledge (Tanaka & Watanabe, 2013). Student involvement in this activity has been demonstrated to have a positive impact on natural cognitive development (Cannady et al., 2019; Lewis, 2016) thereby enhancing the learning process (Cannady et al., 2019).

In addition to presenting information about plants, the plant morphology module includes evaluation questions for students. The evaluation questions in the module assess students' conceptual abilities. It is hoped that through this module, students will demonstrate an improvement in their understanding of the concept of plant morphology. In the process of assessing learning outcomes, students are required to identify and interpret evidence in order to demonstrate their understanding of the material, the extent to which they have mastered it, and the most effective means of achieving the desired outcomes (Utaberta & Hassanpour, 2012). The results of the assessment, as conveyed by the evaluation questions, must provide feedback to both lecturers and students. This feedback allows lecturers to ascertain which students have or have not gained understanding, mastery, and skills in the subject matter. For students who have not yet achieved these aspects, there is a need for for improvement (Mitee & Obaitan, 2015).

The capacity for conceptual understanding is not contingent on grade level; however, students

at higher grade levels tend to demonstrate more sophisticated problem-solving abilities. It is imperative to recognize the significant individual differences that exist in students' conceptual understanding throughout their academic careers. To gain insight into the multifaceted and nuanced ways in which students comprehend learning materials, it is essential to examine factors such as retention (Robinson et al., 2018). The concept of concept mastery is based on cognitive aspects as outlined in Bloom's taxonomy. In their 2001 revision, Anderson and Krathwohl divided cognitive aspects into two dimensions: the knowledge dimension and the cognitive process dimension. The knowledge dimension comprises four categories: factual knowledge, conceptual knowledge, procedural knowledge, and metacognitive knowledge. Concept mastery represents a cognitive aspect that is the most frequently assessed by teachers in schools as a result of student learning in terms of mastery of learning (Sudjana, 2005). Concept mastery represents one of the cognitive aspects that serves as a benchmark for student success in the current learning process. Student concept mastery is an integral component of student learning success, which plays a pivotal role in motivating students to adopt sophisticated learning strategies (Utaberta & Hassanpour, 2012).

CONCLUSION

The project-based plant morphology module's teaching materials have been determined to be valid based on the results of validator assessments. Furthermore, the project-based plant morphology module has received a favorable response, indicating that it has been categorized as a module that is very easy to understand and that can improve concept mastery.

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